Valuation of natural resources: Efficiency and equity

Keyzer, M.A.; Sonneveld, B.G.J.S.; van Veen, W.C.M.

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M.A. Keyzer, B.G.J.S. Sonneveld and W. van Veen

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Centre for World Food Studies of the Vrije Universiteit

Amsterdam, The Netherlands

Abstract. Valuation of environmental goods is a key element in the design of policies that aim at sustainable management of natural resources. Yet, adequate pricing is not realized easily as the excludability problem makes it difficult to protect natural resources from unpaid use and to exercise property rights over them. Moreover, the systems that maintain the regenerative capacity of natural resources operate at higher levels than the individual and their management necessarily involves collective choice, rather than the use of pure market mechanisms**.** Establishing property rights of natural resources is all the more important since the proceeds from these rights can be a substantial factor in poverty alleviation strategies, at both global and local level. This paper reviews the techniques that are used in the valuation of environmental goods and discusses achievements and limitations of current natural resource policies from the point of view of efficiency and equity. We argue that implementation of a trust fund operating via market-based transactions is a promising approach to help achieve simultaneously the goals of efficiency, sustainability and poverty reduction, provided that property rights over the environmental resources are distributed fairly within the generation alive as well as between present and future generations.

Key words: Natural resource valuation, efficiency, equity, intergenerational equity.

1. Scope of the problem

The environment contributes to human well-being in a variety of ways, including the supply of non-renewable resources such as mineral ores and fossil fuels, of renewable resources such as timber and drinking water, and of amenity services such as fresh air for respiration and the scenic beauty of landscapes for tourists. Through these contributions it directly produces economic value. In addition, it contains resources that are currently in affluent supply but could become scarce in the future. Such resources possess a future value referred to as non-use value (Pearce and Turner, 1990).

It seems rather obvious that to avoid overuse and undersupply, these contributions should be priced adequately as for any other good in the economy. However, in practice the use of natural resources is very often free, because protecting them from unpaid use is difficult. This problem is known as the excludability issue. The reasons for non-excludability differ among resources depending on their physical properties. For fresh air, it is clear that one cannot expect every person to pay before breathing, or, more importantly, every company to pay before using up the fresh air quality lost through the exhaust of fumes from factory chimneys. Hence, exercising property rights is difficult for many of the environmental resources, and, conversely, when property rights are not well established over them, few will have an interest and be authorized to act as custodian countering depletion and degradation. Consequently, the markets for these resources will not function properly.

This situation is known as the 'Tragedy of the Commons' (Hardin, 1968), referring to communal rangelands in England that persistently suffered from degradation through overgrazing, as the livestock owners individually enjoyed the benefits of larger herds without having to pay for the forage.

Primitive human communities only engage in gathering and hunting, and hence, in natural resource extraction. As technological skills improve and population pressure keeps on rising, sedentary agriculture becomes a necessity, and with it communities turn to the management of natural resource regeneration, mainly to maintain fertility of the soils. More developed societies have come to recognize that in forestry, fishing and the human habitat at large a similar transition is needed.

However, the management of these regeneration processes differs from regular productive activities in that the systems involved are very large and indivisible, and most importantly, they cannot be closed down should their operation become unprofitable. In many situations, their functioning is complex and full of interactions among multiple stakeholders. Such systems operate at a higher level than the individual household or firm (the 'oikos' of economics) and it is not possible to manage them via pure market mechanisms. They operate in a public domain (the 'polis' of politics) and their management necessarily involves collective choice. Cities, provinces and nations have very similar properties and, consequently, many useful lessons can be learnt from these fields, specifically from urban management and public administration, to avoid tragedies of the commons.

Indeed, for oceans, rangelands or irrigated lands it would, like for cities, be highly improductive to parcel out the whole territory into privately owned units, and public authority is needed that can co-ordinate the decisions of all stakeholders and reward their contributions. River-basin authorities are examples of such institutions. In practice, a combination of public institutions and private firms tailored to the specific local condition is most likely to be effective (e.g. Matsaert et al., 2007), where the public institutions are in charge of the definition of terms-of-reference, selection of the private supplier of the services, and monitoring of the quality of the services provided.

Yet, irrespective of the institutional arrangement chosen two questions have to be addressed: first, how free use can be avoided, and second, who the owner should be to whom payment is to be made. Seriously addressing both questions becomes more urgent every day, especially because several environmental resources are only renewable as long as stocks remain above critical thresholds[1], below which irreversible processes set in leading, among others, to the extinction of species and the loss of cultivable land. Furthermore, fair distribution of property rights could be a powerful vehicle in the fight against poverty, since it would be natural to let the poor share in these rights.

2. Natural resource management

Generally, natural resource management aims at ensuring that resource stocks are conserved in sufficient quantities for the future generations. With respect to non-renewable resources such as fossil fuels, these policies will obviously have to settle for a certain amount of depletion, but this is defensible in the understanding that there always will be sufficient energy from the sun and the oceans, and possibly from nuclear fusion available to let future generations live a comfortable life, provided current generations make sufficient investments in knowledge and new technologies. Indeed, natural resource policies tend to focus on renewable resources so as to keep them productive and to protect their regeneration capacity by keeping their stocks above critical levels. Current concerns about climate change are a case in point.

In addition, richer segments in the population are increasingly willing to pay for resource amenities of natural parks and historical landscapes, both as tourists and as custodians of natural and cultural heritage.

Nature conservation also has important “option value”, because it maintains the genetic biodiversity of species. The genetic resource pool is of particular importance for agriculture since crop cultivation, even in the age of advanced bio-technology, still has to rely on it to maintain productivity be it through breeding or through implantation of genes via genetic engineering.

To address these various concerns, several government policies have been put in place worldwide, most of which are designed to simulate what the market would do, had the excludability problems been resolved and had adequate property rights been introduced. In the sequel, we suppose that the excludability question can be appropriately dealt with. Indeed, modern statistical techniques, satellite imagery, GPS and information processing devices greatly ease the task of coming up with reasonable estimates of the use of natural resources by individuals, making it possible for authorities in charge to settle the accounts, in technically more developed regions through individual taxation, and elsewhere through transfers at community level. Generally, most natural resource policies are still at the stage of simulating a well functioning market by means of dedicated planning procedures, using as policy instruments a mix of quantitative restrictions that limit the use of the natural resource, and taxes on use. Clearly successful implementation of these policies should account for gender related decision making processes as, for example in Africa, the prospects for improving sustainable environments are positively correlated to women's increasing influence in natural resource management (Thomas-Slayter and Sodikoff, 2001).

Among the quantitative restrictions, the strict conservationist measures are the most far-reaching. They are proposed for resources that are deemed essential to the well-being of future generations and whose renewability is very limited. In the natural resource management literature, these measures are being advocated from the perspective of ensuring "strong sustainability"[2] of environmental functions that cannot be substituted for by human capital or man-made goods[3]. For example, few will agree that a nice poem on a nature resort or a 3D-movie of this resort can substitute for an actual visit to that resort. Under strict conservation, resource stocks and environmental quality are to be kept at their current levels (Brekke, 1997) through legislation that bans all use. Less strict conservation allows for limited use and relies on licensing and user quotas as instruments (e.g. emission permits for the use of clean air and clean water).

While powerful in principle as a means to prevent resource exhaustion, quantitative restrictions tend to be less efficient economically, as they restrict individual people in making their choices according to their own preferences and hence hamper the proper functioning of the free market. Yet, these restrictions may be conceived of as a means for allowing future generations to exercise demand for natural resources on present-day markets but then again, there is no way of asking these generations how much they appreciate this intervention.

Taxation of resource use is another way of restricting use and leaves more room for choice by the present generation. It can ensure that the natural resource use carries a positive cost, making resource extraction less attractive and supply more attractive, while promoting the development of close substitutes. Specifically, Pigovian taxes aim at keeping taxation at the level of the market price that the resource would fetch under perfect conditions, had all

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[1] The critical threshold is the minimum size of a natural resource to maintain its own existence.

[2] Strong sustainability is opposed to weak sustainability that allows for substitution of natural capital by manufactured capital.

[3] The ozone layer is one example of an ecosystem service that is difficult for humans to duplicate.

causes of market failure such as excludability and joint use been eliminated. Hence, under Pigovian taxation, the tax levels imposed reflect the individual willingness to pay for negative externalities, while the proceeds are available to finance environmental protection.

As Pigovian taxation attributes a price to all resource use, and through this to all supply flows as well as to all stock levels, it in principle solves the problem of natural resource valuation but only in principle. In practice, the difficulties are on the one hand that it may not be easy even to approximate these ideal levels of taxation, and on the other that the present generation may not be willing to pay this tax.

To deal with the first issue, various techniques have been developed (see Box). Examples of use value approaches are production function analysis and defensive expenditures. Both methods rely on the existence of market prices for end-users of natural resources, yet, they are based on different principles by focussing on the revenues and the cost side, respectively. Conceptually, the most attractive way to conduct valuation based on use value would presumably be to incorporate all the information collected within a simulation model with a detailed representation of the dynamic and geographic dimensions of the relevant biophysical processes and stock balances in an intertemporal welfare framework. A recent study by Albersen et al. (2003) conducted in this spirit but with ample simplification, shows how upstream prices and values can be assigned to water flows and stocks, on the basis of upward calculation, starting from the economic benefit obtained by downstream users. Yet, the drawback of this type of modeling is that it needs vast amounts of statistical measurement and process knowledge, which, all cost issues aside, are simply not available for many branches of natural resource management. Hence, the frequent appeal to the precautionary principle, whereby strict conservationism and prohibitively high taxes are being advocated to avoid uncertain but possibly irreversible damage.

The surrogate markets approach is somewhat subjective with respect to the reference variables used in the comparison, which may, moreover, be correlated with non-environmental values. For example, comparing real-estate prices on the basis of the parks in the neighborhood would grossly exaggerate the contribution of these parks to the prices of houses, because presence of a park is likely to be correlated with many other qualities of municipal services provided to a neighborhood.

The stated-preference methods have the disadvantage that on the one hand interviews may be distorted by strategic biases of respondents, lack of commitment to actually pay the price communicated in the poll, and insufficient coverage of the poll, and on the other hand experimental designs may not be suited to capture the real life situation. Yet, in many situations, for example when development of a completely new park or of a new regime of ecological management are being considered, or when non-use is the actual aim, these less precise techniques have to be relied upon.

Box: Methods of natural resource valuation

- **Use Value**

  When a natural resource has well defined end uses, say, timber, drinking water and tourism for a forest, each with a functioning market, the resource valuation can be imputed from the prevailing market prices of these end-uses.

  - The **production function** method identifies the marginal contribution of the natural resource to the production of a marketed commodity: e.g. water to crop production (e.g. Freeman, 2003; Archaya and Barbier, 2002).
  - The **defensive expenditure** method assigns a price to a natural resource equal to the cost of maintaining its productivity by curing damage from emissions of pollutants and resource degradation (e.g. Tiezzi, 2002).

- **Surrogate Markets**:

  In the absence of a functioning market for an end-use, surrogate markets may be referred to:

  - The **hedonic pricing** method values the presence of natural resources e.g. by comparing prices of houses with otherwise similar characteristics under different environmental conditions (e.g. Taylor and Smith, 2000).
  - The **travel cost** method, measures the value of a recreational site by surveying travelers on the economic costs they incur when visiting the site from some distance away (e.g. Pendleton and Mendelsohn, 2000).

- **Stated preferences**:

  Alternatively, communication with stakeholders may provide additional information

  - The **contingent valuation** method elicits information on willingness to pay from survey questionnaires and interviews (e.g. Kolstad, 2000; Mitchell and Carson, 1989).
  - The **conjoint stated preference** methods undertake experiments involving contingent ranking, or contingent choice, among alternatives that provide different levels of non-market goods (e.g. Roe et al. 1996).

Leaving aside the technical difficulties in obtaining Pigovian taxes, the current interest in establishing property rights[4] over environmental resources seems to result mainly from the growing understanding that markets do not function well with taxes alone. Private property rights are needed to let the private sector perceive free use of natural resources as a form of robbery. Moreover, it appears that the sums at stake to pay the owners might be substantial. Indeed, under appropriate pricing and given the vital role of environmental services in the world economy, the sustainable management of the natural base could become a highly

[4] Property rights should be secure, indefinite, enforceable and legally transferable (Panayotou, 1992).

profitable venture. For example, though such calculations obviously remain debatable, it is noteworthy that Costanza et al. (1997) estimate the present value of the (potentially indefinite) stream of environmental services at up to 54 trillion US dollars in 1997 worldwide.

However, distribution of property rights is not an easy task. First, as mentioned earlier, the excludability problem is firmly anchored in the biophysical nature of the processes at stake. For instance, under traditional conditions the partitioning of a pastoral dryland among multiple stakeholders is not a viable option, as the herds have to migrate with the seasons. The same applies to river basins, forests and oceans. Second, conservation of natural resources usually requires intervention at higher administrative levels, basically because the high set-up costs of degradation control and infrastructural development cannot be borne by individuals. Third, sustainability requires that future generations receive a sufficiently large share of the property rights. There is need for an institution that can represent their interests. Finally, the distribution of property rights may have serious implications for equity and social stability, when the poor are denied access to previously common resources, whereas more powerful groups reap the benefits from the newly created rights. We consider these four pitfalls, starting with the last one.

3. Distribution of the proceeds from environmental resource use

The concern for intergenerational equity that motivates natural resource valuation should not dwarf the concern for intra-generational equity. Hence, the issue should be addressed as to whom the payment should be made within the present generation (Keyzer and Van Veen, 1997). Current practice essentially follows the principle of occupation, whereby the property over the resource is attributed to its current users. This is highly to the advantage of the rich nations. For example, by distributing emission rights of pollutants (the bads) rather than the clean air (the good) itself, the Kyoto agreement on mitigation of greenhouse gases attributes property rights in proportion of use. Specifically, the agreement implies that the Pigovian-like ecotaxes currently paid by the private sector in each country eventually accrue to the owners of the CO2-emission permits. These are largely the public sectors of the polluting countries themselves, but the agreement also allows for international trade in permits (joint implementation), while countries that grow new forests or provide other additional sinks of greenhouse gases are rewarded financially.

Instead of assigning the emission rights to the polluting countries it would seem more natural and fair to entitle all human beings to an equal share in these permits, since no individual or state has so far established sovereign rights over the climatic ecosystem. Such a distribution would most likely benefit the poor, who spend relatively little on energy-intensive goods, and would, therefore, earn more from selling their emission rights than they spend on emission taxes via the tax-inclusive price of the goods they purchase. Hence, they would derive a positive net revenue from the arrangement. Clearly, it would be difficult to set up a system of payments that reaches every individual on earth but for those who are unable to participate directly, some collective arrangement could be established. In this way, everyone could be assured of a basic income. This also establishes a strong link between poverty alleviation and environmental policies and makes it attractive for the poor to support policies that preserve the environment. In addition to receiving positive net transfers, as they spend less on emissions than they are entitled to, they would also find it rewarding to produce non-fossil energy and to engage in activities that ensure absorption of greenhouse gases.

4. Maintaining intergenerational equity: a trust fund approach

Even if competitive markets could be established for all natural resources, and a full system of property rights could be introduced, serious environmental degradation might persist, essentially because present generations are by necessity the ones to decide (Pezzey, 1992). Mourmouras (1993) and Krautkraemer and Batina (1999) have studied the implications of this principle of 'grandfathering', whereby man-made and natural capital are initially given in exclusive property to the generation that happens to be alive and that sells the capital it owns to its successor in order to provide for old age, and so on in every period. After showing that this savings mechanism might be insufficient to prevent a gradual reduction in human welfare, these authors argue that the economic analysis of equitable resource use has to advance beyond the efficiency argument, as in Bromley (1990).

One possible answer could be that it still is possible to prevent such a welfare decline by resorting to the strictly conservationist 'zero extraction' measures discussed earlier but this would go at the expense of efficiency, while the Pigovian taxes that aim at addressing this issue were seen to have their limitations as well (Howarth, 1998). To combine dynamic efficiency with sustainability, one would need a transfer mechanism that redistributes income among generations while the market would generate the prices. To this end, Gerlagh and Keyzer (2001) have suggested creating a fund that can act as trustee for future generations and in which present generations are represented as well. To avoid disagreement about management and distribution, this fund would entitle all individual members of present and future generations to an equal claim over natural resource use during their lifetime. Through net transfers, this trust fund would offer compensation in line with the Polluters Pay Principle: a generation using more of the resource than its entitlement will have to compensate future generations for the degraded environment they have to live in by leaving more man-made capital as bequest, and conversely. Being market-based, that is computing the transfers on the basis of the market prices of the resources, the trust fund would be as efficient as grandfathering while protecting the welfare of future generations.

In this way, the trust fund approach presents several advantages: (i) it can maintain common property over natural resources that can not easily be distributed over individual owners and, nonetheless, operates via market-based transactions, (ii) it can help achieve simultaneously the objectives of dynamic efficiency and sustainability, (iii) it tends to raise the income of the poor whose share in resource ownership will generally exceed that in resource use, also because the resource pricing will reward resource regeneration activities, (iv) it operates by contractual arrangements whereby all owners including future generations are represented with clear claims, and (v) it has a flexible setup: stakeholders in the use of a particular resource may form a dedicated club, with the special feature that future generations are being represented in its rules and regulations and that the property rights are not limited to users.

Thus, it might seem that the fund has an answer to each of the four pitfalls listed earlier. Indeed, for resources that the poor consume in small quantities, such as clean air, the arrangement might work. However, for other resources, a large number of hurdles would have to be overcome for the fund to function well in practice. For example, consider a case of soil degradation by water erosion in an area occupied mainly by poor farmers owning small plots of land. Under these conditions, the farmers already are the owners of the main natural resource they depend on. Nonetheless, given their day-to-day pressure to survive, they will often be forced to ignore their losses of top-soil from rains and of soil-fertility from insufficient replenishment of nutrients. In such situations, explicit conservation schemes are called for to prevent further resource degradation, as a complement to the market mechanisms upon which the trust fund will tend to rely.

Yet, if the trust fund was to generate sufficient revenue for these empoverished population groups, this might enable them to adopt a more long-term perspective and to relieve the pressure on the land, say, by purchasing fertilizers to replenish the soil, by building terraces to prevent erosion, by investing in non-farm activities, and by purchasing food on the market from the transfers received. Furthermore, a government recognizing the public interest of protecting the scenery of the region might be willing to co-sponsor conservation projects that would in turn offer additional employment to the farmers concerned. Thus, rewarding resource owners for their role as custodians is an important mechanism for simultaneously alleviating poverty and conserving natural resources (Carter and Currie-Alder, 2006). The successful participation of local communities in protecting the national parks of South Africa is a promising example in this respect.

5. Conclusion

To sum up, despite the many problems of implementation, the trust fund approach seems a promising one, and might offer a powerful device to help achieve simultaneously the goals of efficiency, sustainability and poverty reduction. Basic to the approach is recognition of the principles that environmental resources should be priced adequately and that property rights over them should be distributed fairly within the generation alive as well as between present and future generations. Yet, putting these principles into practice is not easy. Resource pricing requires the excludability problems to have been addressed satisfactorily, and even then additional policy instruments may have to be relied upon, because the underlying environmental processes are often lumpy, indivisible and characterized by thresholds below which irreversible processes lead, for example, to reduced biodiversity and loss of top soils. In such situations, conservationist measures have to be resorted to, implemented either through quantity restrictions or through Pigovian taxes, both computed through dedicated planning procedures. Finally, even with the trust fund and all the planning apparatus in place, the strategies can only succeed as long as the current generation is willing to accept the sacrifice involved. Hence, not surprisingly, political will, rather than technical feasibility, appears to be the major bottleneck in the end.

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